D3 (HP)

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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO VIBRATION DETECTORS

(71) We, THE MARCONI COMPANY LIMITED, of English Electric House, Strand, London, W.C.2, a British company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to vibration and more particularly, though not exclusively, to vehicle detectors by which is meant, in this specification, a device which will respond to the passage of a vehicle across it, to produce a signal which can be used for such purposes as directly or indirectly operating traffic signals or counting vehicles to obtain data for traffic control, road development schemes and the like.

There are numerous known forms of vehicle detector. Probably the one most commonly in use is that comprising a pneumatic tube in a structure which is sunk into a road and extends transversely with respect thereto. The structure is such as to provide, in the surface of the road, a rectangularly framed rubber or like "mat" and, when a vehicle passes across it, its weight causes compression of the air in the pneumatic tube and the consequent rise in pressure operates a diaphragm-actuated switch to produce an electrical signal to perform whatever function is required of the vehicle detector. Somewhat similar arrangements utilising, however, liquid filled hydraulic tubes instead of air-filled pneumatic tubes have been proposed. Among the many other forms of vehicle detectors which have been proposed are those using the weight of a passing vehicle to deform a piezo-electric crystal to produce a voltage piezo-electrically; or to apply pressure to a pressure-sensitive electrical resistance; or to alter the spacing between the plates of an electrical condenser and thus vary its capacity; or, more simply, merely to close (or open, but usually to close) the contacts of a switch.

The practical requirements for a satisfactory vehicle detector are, however, difficult to satisfy and so far as the present applicants are aware, none of the detectors so far proposed satisfy them all to the extent desired. These requirements include (they are not given in order of importance) that they shall have a high degree of certainty of action; shall respond satisfactorily to vehicles which may be of any weight within a wide range of practical speeds; shall be capable of giving satisfactory service when merely laid across the surface of the road, as is often desirable where only temporary installation is wanted; shall be capable of giving satisfactory service when permanently installed in a duct in the road, i.e. beneath or flush with a road surface, and shall be reasonably easy and cheap so to instal; shall require a minimum of power for their operation; shall be readily capable of installation so as to have minimum liability to external interference and minimum liability to response otherwise than to passing vehicles; shall have minimum liability to deterioration from wear and tear and shall lend themselves to installation with good protection from damage by moisture or weather; and shall give reliable and readily recognisable and utilisable signals in response to the passage of vehicles. The present invention seeks to provide improved vibration detectors which shall be simple, of low cost, and yet will satisfy these requirements to a high degree.

The present invention makes use of a not very widely known phenomenon to which the name Tribo-electrical effect has been and is herein applied. It is often found that certain electrical cables produce noise voltages when subjected to mechanical shock or stresses and much trouble has been experienced as a result of such noise voltage generation in insulated cables employed for signal transmission. Experiment indicates that if a cable having conductors separated by an insulating dielectric—for example a co-axial cable having an inner conductor insulated from the associated outer conductor by a sheath of insulating dielectric—

is subjected to mechanical shock or vibration, noise voltages will appear between the two conductors if the mechanical contact between the dielectric and either of the conductors it separates electrically is varied by the said shock or vibration. Thus, in the case of an ordinary co-axial cable with an inner conductor, an outer conductor, and insulating material therebetween, small gaps are in practice left between the outer surface of the insulation and the inner surface of the outer conductor and vibration or shock causes these gaps to vary in position and/or dimensions thus altering the contact conditions between the outer surface of the insulation and the inner surface of the outer conductor, the vibrations or shocks will cause the production of voltages, (which may vary between fractions of a milli-volt and several volts, depending on circumstances) to appear between the two conductors. The effect which produces such voltages—which are, of course, a nuisance to be avoided as far as possible, in signal cables—is what is herein termed Tribo-electrical effect.

The physical mechanism underlying the Tribo-electrical effect is somewhat obscure but it is believed (although the invention does not depend on correctness or otherwise of the theory) that it is due to the generation of electricity by friction and/or to the displacement of residual electric charges due to relative motion between dielectric surfaces and a cable conductor. It appears clear that the phenomenon owes little or nothing to capacity variation of the cable though such variation may sometimes accompany Tribo-electric voltage generation to some small extent.

According to this invention a vibration detector comprises a tubular outer conductor, and an inner conductor with insulating solid dielectric extending between said conductors, the inner and outer conductors being so arranged that they do not have a common longitudinal axis and so that a plurality of points or areas of contact are provided between said dielectric and at least one of said conductors, and means for mounting said conductors so as to subject them to a vibration to be detected to an extent necessary to disturb said points or areas of contact and means for taking off voltages generated as the result of said contact disturbance.

For use as vehicle detectors the detectors in accordance with the invention will be positioned on or in ducts in the road surface so as to subject them to vibration from passing road vehicles.

Preferably the tubular outer conductor is in the form of a length of metal tube and the inner conductor is in the form of a wire with a sheath of dielectric thereon; the dielectric covered inner conductor resting lightly on the inside of the outer conductor. The dielectric coated inner conductor may be similar to the dielectric coated inner of a flexible high frequency co-axial cable.

By the term "resting lightly" when applied to the dielectric covered inner conductor is meant that the said inner conductor is free to move within the tubular outer conductor and rests upon the inside of the tubular outer conductor under its own distributed weight.

Another embodiment comprises a length of flexible high frequency co-axial cable consisting of a central conductor, a sheathing of dielectric thereon, a braided co-axial conductor on the dielectric sheathing, and a covering of dielectric on the braided conductor, said length of co-axial cable being run along loosely inside the outermost conductor in the form of a metal tubular member embracing the cable.

It is to be understood that, in all cases, the conductors from between which Tribo-electrical voltages are taken off (normally at one end) in a detector in accordance with this invention are insulated from one another over their whole lengths i.e. the only connection between them is by the load to which the Tribo-electrical voltages are fed.

The combination of conductors and dielectric to form a vibration detector in accordance with this invention may conveniently be housed in an elongated bore in a protecting and enclosing housing which may be of any mechanically suitable material. Thus, for example, the housing could be of rubber or similar flexible material and be of segmental section with a central bore to receive the detector. Such a structure could be simply laid across a road and suitably fixed to its surface; or it could be laid in a shallow duct across a road so that the arcuate face of the segmentally sectioned housing projected slightly above the general road surface; or it could be sunk in a shallow covered-over duct so as to be flush with or to lie wholly a short distance beneath the road surface, vibration from passing road vehicles in the latter case reaching the detector through the road. It is also possible to use a housing made of metal. Such a housing could also with advantage be of generally segmental section adapted to be recessed in a road surface with the arcuate face uppermost. Conveniently such a housing could be formed integrally with a tube-like portion projecting downwards from the flat face thereof, the cable constituting the detector proper being run inside the tube-like portion. If desired the said tube-like portion could be arranged to constitute one conductor of a detector in accordance with this invention.

The invention is illustrated in the drawings accompanying the provisional specification, in which

Figure 1 shows one simple embodiment;

Figures 2 and 3 show two forms of housing; and

Figure 4 is a diagram of a suitable amplifier circuit for receiving Tribo-electrical voltages

produced by a detector in accordance with this invention, and in the drawing accompanying this specification the single figure of which has for convenience been numbered 5, so as to follow consecutively on from the provisional specification figures, and which is a diagrammatic cross-sectional view through a further embodiment of the invention.

Referring to Figure 1, the vehicle detector therein shown comprises an outer metal tube 1 in which is laid a length of dielectric covered conductor 2. The conductor 2 and its covering dielectric 3 may be similar to the inner conductor and its covering insulation of a flexible co-axial HF cable, the outer copper braiding and any covering thereon having been removed. The covered conductor 2—3 has an overall diameter less than the inner diameter of the tube 1 and simply rests under its own weight on the interior surface of the tube such that the conductor 2 does not have a common axis with tube 1 and a plurality of light random points or areas of contact are formed between the dielectric and the outer conductor. At the left hand side of Figure 1 the tube 1 may be closed off in any convenient manner. The insulation on the conductor 2 is such as to prevent all electrical contact between it and the tube 1. At the other end of Figure 1 leads L connect the conductor 2 and the tube 1 to the input terminals of an electronic signal amplifying utilisation unit AU of any suitable desired form.

A detector as shown in Figure 1 may be housed in any of a variety of different forms of protecting housing. For example there may be employed a segmentally sectioned rubber or like strip 4 as shown in Figure 2 and having a bore 5 to receive the tube 1 of Figure 1. When the detector is in the housing the bore may be suitably plugged at its ends to provide weather protection if that is not already sufficiently provided by the construction of the detector itself. The strip 4 may then be fixed to a road surface to extend partly across the road or it may be buried in a shallow duct in a road either with the curved upper surface of the strip just proud of the road surface or entirely buried a short distance beneath the road surface.

Figure 3 shows another suitable form of housing adapted for grouting into a duct in the surface of road by grouting brackets (not shown). The housing in Figure 3 is of metal—e.g. extruded aluminium—and has an integrally formed dependent tubular portion 6 in which the detector may be housed. If desired the tubular portion 6 may itself constitute the outer conductor of a detector which, in principle, is as shown in Figure 1, i.e. covered cabling as at 2—3 of Figure 1 may be run loosely along inside the tubular portion 6. If this is done precautions must in practice be taken to exclude moisture and so on from the portion 6 for, in such an embodiment, the portion 6 will be depended on to prevent deterioration or interference by weather and moisture.

Figure 4 shows a convenient form for an amplifying stage for inclusion in an amplifying and utilisation unit such as the unit AU of Figure 1. The leads L of Figure 1 are connected to the terminals so referenced in Figure 4 so that Tribo-electric voltages are applied through a condenser 7 to a transistor amplifier 8 across which negative feedback is applied by a condenser 9. The output terminals 10 feed into utilisation circuits (not shown) chosen in dependence on the function required to be performed e.g. to operate a counter or to actuate traffic signals.

Figure 5 shows a vibration detector in accordance with the invention which is suitable for detecting vehicles; in a further form of housing, positioned in a duct or channel in the surface of the road. The same reference numerals have been used in Figure 5 as in Figure 1 for like parts. The metal tube 1 is fixedly connected to a metal plate 11 and both are embedded in a rectangular block of rubber or rubber-like material 12. The rectangular housing formed by the block 12 is shown positioned in a channel in a road surface 13 such that the upper surface of the plate 11 lies flush with the road surface. Adhesive material 14 is used to bond the housing to the road surface 13. As shown the output from the vehicle detector is fed via leads L to the electronic signal amplifying utilisation unit AU as before.

The operation of this detector is similar to the previous detectors except that the rubber-like material 12 isolates the detector from road surface transmitted vibrations to safeguard against the making of incorrect vehicle detections as a result of random vibrations in the road surface caused by other means e.g. road drills or pedestrian traffic. The metal plate 11 forms a hardwearing surface for the detector rendering it less susceptible to wear and damage.

WHAT WE CLAIM IS:—

1. A vibration detector comprising a tubular outer conductor, and an inner conductor with insulating solid dielectric extending between said conductors, the inner and outer conductors being so arranged that they do not have a common longitudinal axis and so that a plurality of points or areas of contact are provided between said dielectric and at least one of said conductors, and means for mounting said conductors so as to subject them to a vibration to be detected to an extent necessary to disturb said points or areas of contact and means for taking off voltages generated as the result of said contact disturbance.

2. A vibration detector according to Claim 1 wherein the tubular outer conductor is in the form of a length of metal tube and the inner conductor is in the form of a wire with a dielectric sheath thereon, the dielectric covered

inner conductor resting lightly on the inside of the outer conductor.

3. A vibration detector according to Claim 1 comprising a length of flexible high frequency co-axial cable consisting of a central conductor, a sheathing of dielectric thereon, a braided co-axial conductor on the dielectric sheathing, and a covering of dielectric on the braided conductor, said length of co-axial cable being run along loosely inside the outermost conductor in the form of a metal tubular member embracing the cable.

4. A vibration detector according to any one of the preceding claims for detecting the passage of vehicles across it mounted in an elongated bore in a proctecting and enclosing housing.

5. A vehicle detector comprising the vibration detector according to claim 4 wherein said housing is of rubber and is of substantially segmental cross-section.

6. A vehicle detector comprising thevibration detector according to claim 4 wherein said housing is in the form of a block of rubber or rubber-like material having one surface with a metal plate embedded therein so as to be flush with the surface thereof, said detector being fixedly connected to said plate and in a bore or channel in said block whereby the whole block may be positioned in a channel in a road surface with said metal plate flush therewith, the metal plate protecting the detector from wear and damage by vehicles and the rubber-like material insulating the detector from road transmitted shocks.

7. A vibration or vehicle detector substantially as hereinbefore described with reference to Figures 1 and 2 or Figures 1 and 3 of the drawing accompanying the provisional specification or with reference to Figure 5 of the accompanying drawing.

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1209506 PROVISIONAL SPECIFICATION
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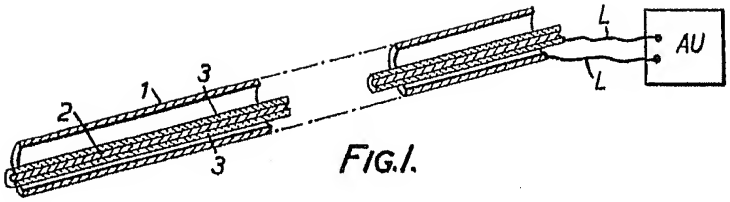

FIG.1.

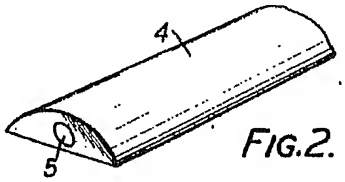

FIG.2.

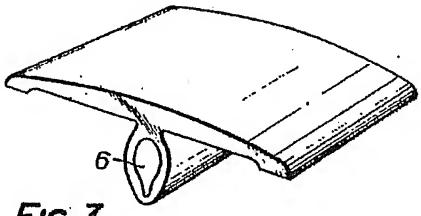

FIG.3.

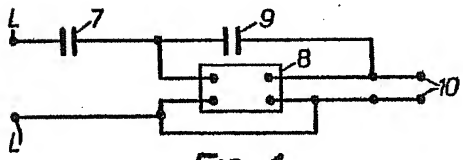

FIG.4.

1209506 COMPLETE SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

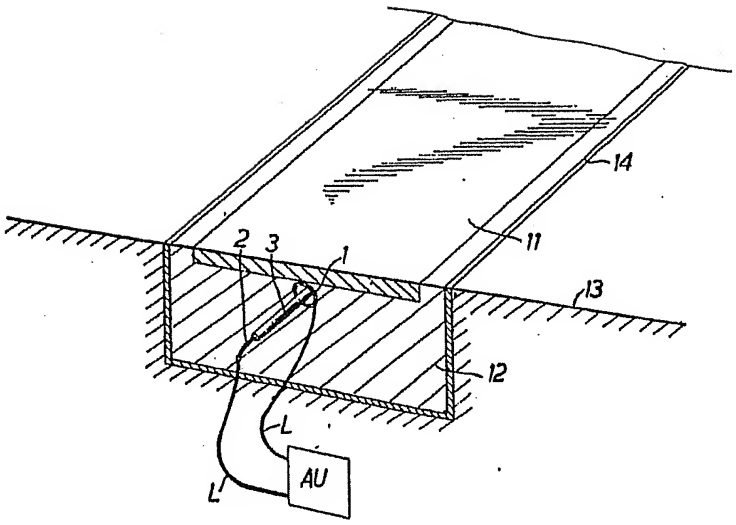

FIG.5.